

# *Manufacturing Readiness Levels (MRLs) and Manufacturing Readiness Assessments (MRAs)*



**U.S. AIR FORCE**



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# Outline



- Why Manufacturing Readiness?
- Manufacturing Readiness Levels & Assessments
- Implementation of MRLs
- MRA Tools
- Example results
- Policy Status
- Closing Thoughts



# Why Manufacturing Readiness?

## Manufacturing & Industrial Base Challenge



- **Consensus among Congress, OSD, CSAF, GAO:**  
*“Advanced weapon systems cost too much, take too long to field, and are too expensive to sustain”*
- **GAO study of 54 weapons programs:**
  - Core set of 26 programs: RDT&E costs up by 42% (\$42.7B total) and schedule slipped by 20% (2.5 years on average)
  - Characteristics of successful programs (GAO):
    - *Mature technologies, stable designs, production processes in control*
    - *S&T organization responsible for maturing technologies, rather than program or product development manager*
- **Products made by immature manufacturing processes generally:**
  - **Cost more**
  - Are prone to quality problems
  - Experience **schedule delays**
  - **May not perform** the same
  - Are less reliable in service



# Today's Air Force Reality



- **Diminishing manufacturing infrastructure**
  - People, policy, programs gutted
  - Lost recipe on how to manage manufacturing risk
  - Won't get infrastructure back, but still need to manage and mitigate manufacturing risk
- **Utilize MRL/MRA as a tool**
  - Supports knowledge-based acquisition
  - Integral to Systems Engineering Plan
  - Essential for effective and efficient transition of capability to the warfighter



# Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRLs)



- TRLs provide a common language & widely-understood standard for:
  - Assessing the **performance maturity** of a technology and plans for its future maturation
  - Understanding the level of **performance risk** in trying to transition the technology into a weapon system application

***TRLs leave major transition questions unanswered:***

Is the technology producible?

What will these cost in production?

Can these be made in a production environment?

Are key materials and components available?

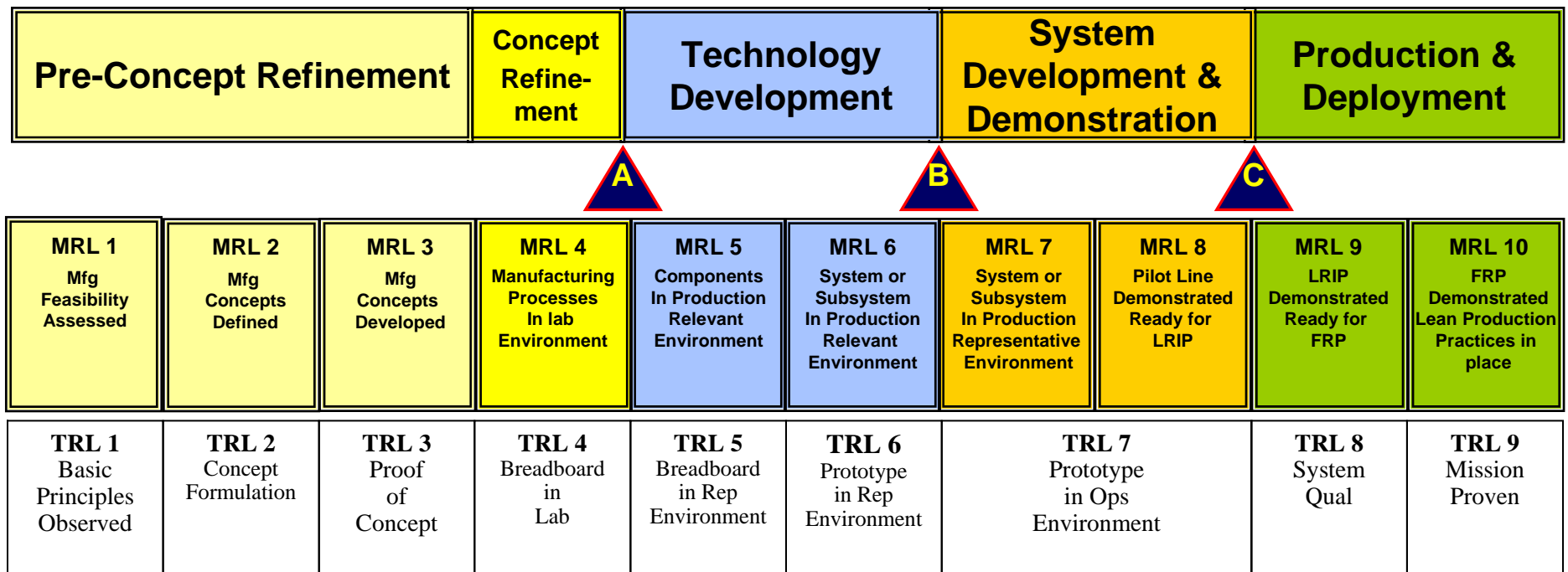
***MRLs assist in answering these questions***

- MRLs provide a common language and standard for
  - Assessing the **manufacturing maturity** of a technology or product and plans for its future maturation
  - Understanding the level of **manufacturing risk** in trying to produce a weapon system or transition the technology into a weapon system application



# MRL Relationships

## *Relationship to System Acquisition Milestones*



## *Relationship to Technology Readiness Levels*



# Nine MRL Evaluation Criteria ("Threads")



1. Technology and Industrial Base
  - Technology maturity, technology transition to production, ManTech development
2. Design
  - Producibility program, design maturity
3. Cost and Funding
  - Production cost knowledge (cost modeling), cost analysis, mfg investment budget
4. Materials (raw mats, components, subassys, subsystems)
  - Maturity, availability, supply chain management, special handling
5. Process Capability and Control
  - Modeling & Simulation (product & process), mfg process maturity, process yields/rates
6. Quality Management, to include supplier quality
7. Manufacturing Personnel, to include specialization, training, & certification
8. Facilities, to include capacity and plant layout & design
9. Manufacturing Management
  - Manufacturing planning and scheduling
  - Materials planning
  - Tooling and special test equipment





# What is a Manufacturing Readiness Assessment?



- An Assessment of a Program's Readiness to Manufacture and Produce its Intended Design
- A Tool to Develop and Implement -
  - **Manufacturing Risk Mitigation Plans**
  - **Business Strategies**
    - Effects of Design Changes (Planned Upgrades, Spiral)
    - Pricing Agreements (Long Term vs. Single Lot)
    - Capital Investment Plans (Contractor and/or Government)
- Results in an Assignment of MRLs to Key System Components and Development of a Manufacturing Maturation Plan as Required



# MRA Deliverables



Provide briefing and/or written report

- Identify current MRL/target MRL
- Identify key factors where manufacturing readiness falls short of target MRL
  - Define driving issues
- Identify programs and plans to reach target MRL
- Assess type and significance of risk to cost, schedule or performance
- Next step: Stay engaged to assist in implementing and executing the Manufacturing Maturity Plan



# Implementing MRLs: Who is Using Them?



- Mandated by AFRL for all Category 1 hardware ATDs and certain high-visibility programs
- Selected Air Force acquisition programs, including all at AAC
- Army using on Future Combat Systems development efforts
- Missile Defense Agency
- Industry has adopted and is using MRLs within their gated processes



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*And the list is growing.....*



# MRL Implementation Approach



- Conduct pilot MRAs on various programs
  - Hardware-intensive Category 1 ATDs
  - Weapon system acquisition programs
- Conduct tailored training for key program personnel
  - Category 1 ATD IPTs, ACAT pilot program, and Air Force Product Centers
  - Transition training
    - DAU for awareness and policy
    - AFIT for in-depth MRA and manufacturing instruction
- Put MRLs into policy documents
  - AFRL, AFMC, AF, OSD
- Socialize MRLs whenever possible
- Develop and deploy Manufacturing Readiness products
  - Continuously refine products based on feedback, need



# MRL/MRA Products/Tools



- Most of our MRL products/tools have been developed with other Services and industry
  - MRL definitions, entry/exit criteria
  - MRL training blocks (2-hr, 4-hr, multi-day)
  - MRA Deskbook (modeled after TRA Deskbook)
  - Pre-MRA self-assessment questionnaire
  - Excel-based MRA tool
  - Draft DoD and AF policy
  - Defense Acquisition Guidebook language
  - MRA “frequently asked questions” repository



# MRA Results Examples



- Focused Lethality Munition - ready for LRIP
  - Eglin High Explosive Research Development facility originally assessed at MRL 5 (May 07); now at MRL 8
  - Aerojet composite warhead case originally assessed at MRL 5 (March 07); now at MRL 8
- AMRAAM C-7 - production rate increased from <10 to 28+ per month
- F135 Propulsion Persistent Strike - accelerated F135 thrust improvement by ~4 yrs w/plan to mature advanced casting producibility from MRL 3 to 5
- MQ-9 Reaper



# MRL Policy Status



- Goal: Establish manufacturing risk management as a tenet of acquisition management
  - Recommended levels
    - MS A – MRL 4
    - MS B – MRL 6
    - MS C – MRL 8
    - FRP – MRL 9
- Not designed to be a 'go/no-go' criteria
- OSD (AT&L) recently sent a draft policy memo to the Services
  - Services and OSD Systems Engineering nonconcurred; suggested MRL use at MS C only
  - Expect AT&L to press forward with revised language in coming weeks



# Some MRA Lessons Learned



- Process is more effective if company and program office are actively engaged in the assessment
- System integration and test operations are often ripe for maturation efforts
- With few exceptions, requires 'feet on the (shop) floor'
- Resources required to conduct an MRA will vary significantly
  - Not all programs are equal
- Subject matter expertise is needed to 'do it right'
- Templates and guidelines developed
  - Not a 'one size fits all' solution
  - Engineering skills/judgment still needed
  - Must avoid a checklist mentality





# Closing Thoughts



- Feedback from those who have applied MRLs thus far has been positive
- Expectations management is important; MRLs will not solve world hunger
- Congress, National Defense Industry Association and other industry consortia have been vocally supportive
- Policy implementation pending, but many are using as a best practice and DAU is including MRLs in courses
- Fits well within Defense Systems Engineering construct, but should not be diluted to the point of becoming ineffective (e.g. PRRs)